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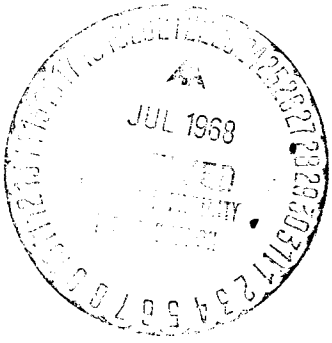

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ABSTRACT. For determination of spatial coordinates of Noctilucent Clouds, measurements of cloud details and of reference stars in each photograph have been made by means of a measuring microscope. For all reductions a calculation programme was compiled for the Latvian State University electronic computer BESM-2M. First results of these calculations are given in this article.

Table 1 contains data of measurements of Noctilucent Clouds which appeared at night of the 30.6/1.7. 1961. The first column contains number of the pair of photographs and moment of expositon; the second column - number of the measured detail; the third, fourth and fifth respectively -- the height of detail in km, its geographic latitude and longitude.

In table 2 velocity and direction of movement of the Noctilucent Clouds are given. The first column contains number of measured detail, the second and third - the horizontal and vertical velocities and the fourth column - azimuth of direction of the movement.

Tables 3 and 4 contain measurement results of Noctilucent Cloud photographs on 30.6/1.7.1964. In table 5 velocities of clouds of the night 14/15.6.1959 are given.

The horizontal velocities of some of measured details are very great - up to 170 m/sec. Their movement is directed in most cases to the South-West. The velocities of the vertical movements are also very different. In some cases they reach 20 m/sec and more.

[Abstract taken from the original text.]

The study of noctilucent clouds is of great significance /47* for the investigation of the upper layers of the atmosphere. On the basis of altitude determination and geographical coordinates of noctilucent clouds, as well as velocity and direction of their movement, conclusions can be drawn about

*) Numbers in margin indicate pagination of foreign text.

the kinematics of the upper layers of the stratosphere and about physical conditions at corresponding altitudes.

The spatial coordinates of noctilucent clouds can be determined by means of simultaneous photographs, taken from two or more observation points. Beginning in 1958 in the Latvian section of the All-Union Astronomical-Geodetic Society, and in recent years at the Astronomical Observatory of the Latvian State University, a large number of base photographs of noctilucent clouds suitable for processing were obtained.

A simplified method was used to determine the spatial coordinates of noctilucent clouds. Simplification was attained in the main as a result of introduction of rectangular equatorial coordinates.

A large amount of observation material must be processed to study the kinematics of noctilucent clouds. In this connection, a program was set up for calculating the coordinates of noctilucent clouds on the electronic calculating machine BESM-2. A detailed description of the method and program, as well as the first results, are given in article [1]. The present article gives the results of further study of the observation material. Vertical and horizontal velocities, as well as direction of their movement, are given for some noctilucent cloud details which can be observed on at least two pairs of simultaneous photographs. The tables with the results are at the end of this article.

Three pairs of photographs, taken on the night of June 30/July 1961 at observation points in Riga and Sigulde, were processed more thoroughly. In Table 1, the first column shows the number of the pair of photographs (from I to III) and the time at which exposure was made (Moscow time, decreed); the second column shows the number of the measured detail of noctilucent cloud (if one detail was measured on two or three pairs of photographs, its number is repeated a corresponding number of times); the third column shows the altitude in km., and the following columns show the geographical latitude and longitude of the noctilucent cloud detail's projection onto the earth's surface in degrees.

Table 2 shows the velocities and the directions of movement of the noctilucent clouds for the same appearances. As three consecutive pairs of photographs were processed, the velocities were determined by pair I-II and pair II-III (shown in the upper part of the table). The first column shows the noctilucent cloud detail number (the numbers correspond to those given in the previous table); the second and third columns show respectively the horizontal and /48

vertical velocity components (vertical velocity is negative during downward movement), and the fourth column shows the azimuth of the direction in which the noctilucent cloud details were moving (astronomical azimuth was measured from the South point). The same values are then shown for photographs of pair II-III.

TABLE 1

Pair No., beginning of exposure	Detail No.	Altitude	Latitude	Longitude
I $00^h20^m00^s$	1	82,7	57°67	20°55
	2	80,7	57,67	20,74
	3	83,9	57,77	20,49
	4	85,2	57,78	20,51
	5	81,1	57,94	20,92
	6	82,7	58,05	20,75
	7	83,5	58,10	20,66
	8	82,6	58,14	20,60
	9	82,6	58,12	20,63
	10	80,0	58,16	20,60
	11	83,2	58,25	20,36
	13	82,9	58,42	20,10
	15	83,4	57,98	19,50
	16	87,1	58,00	19,21
	17	83,0	58,00	19,56
	18	81,9	57,68	20,51
	19	81,0	57,73	20,52
II $00^h22^m00^s$	1	80,6	57,63	20,67
	2	84,0	57,67	20,62
	3	85,2	57,73	20,47
	4	87,3	57,77	20,45
	5	83,2	57,92	20,78
	6	82,6	57,99	20,68
	7	83,7	58,04	20,59
	8	83,2	58,10	20,51
	9	83,4	58,07	20,54
	10	83,0	58,13	20,44
	11	82,7	58,18	20,32
	12	83,3	58,17	20,34
	13	84,8	58,33	20,03
	14	86,3	58,39	19,92
III $00^h25^m00^s$	6	84,1	57,92	20,49
	7	82,8	57,94	20,52
	8	83,0	58,02	20,39
	9	82,7	57,97	20,47
	10	81,4	58,03	20,40
	11	81,1	58,08	20,28
	12	82,9	58,10	20,23
	13	81,2	58,16	20,14
	14	81,1	58,19	20,11
	20	82,4	57,66	20,90
	21	86,1	57,69	20,73

TABLE 2

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Detail No.	I-II			II-III		
	Horiz. veloc. m/sec	Vert. veloc. m/sec	Azi-muth	Horiz. veloc. m/sec	Vert. veloc. m/sec	Azi-muth
1	72±10	−17±10	306°			
2	59	+28	92			
3	32	+11	19			
4	31	+17	71			
5	70	+18	71			
6	66	−1	28	73	+8	59°
7	62	+1	36	70	−5	28
8	62	+5	44	55	−1	28
9	65	+6	43	69	−4	28
10	85	+24	64	60	−9	14
11	66	−4	17	60	−9	13
12				58	−2	41
13	92	+15	23	110	−20	341
14				44	−28	334

Observation data for the 1964 season are in course of being processed. Tables 3 and 4 give some results of spatial coordinate determination and of the velocities of the noctilucent cloud detail for the appearance on June 30/July 1, 1964. These tables are similar to Tables 1 and 2.

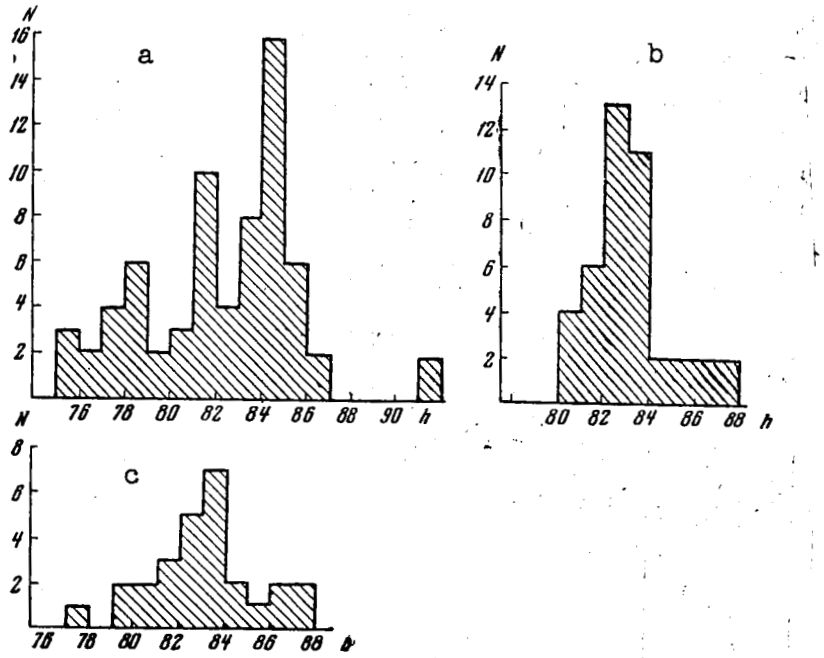
Table 5 gives the velocity values for seven details of a noctilucent cloud appearance on July 14/15, 1961. Results of the calculations for the altitude and the geographical coordinates for 68 points of noctilucent cloud details in this appearance are given in article [1].

The degree of accuracy in determining the spatial coordinates of noctilucent clouds depends on many factors: /50
on the length of exposure, on the type of noctilucent cloud detail, and on the velocity of its motion.

On the average, the margin of error in determining noctilucent cloud altitude is $\pm$ 1 km, while for the velocity of their movement, in cases where photographs are taken at two-minute intervals, the degree of accuracy can be estimated to be $\pm$ 10 m/sec.

The diagrams in the drawing show the distribution of a number of noctilucent cloud points along the altitude h for the examined appearances of 1959, 1961, and 1964.

The maximum number of points in all cases is found approximately at an altitude of 82-84 km. Note the wide /51
range of altitudes at which formation of noctilucent clouds



Distribution of a number of noctilucent cloud points by altitude h.

a - in 1959; b - in 1961; c - in 1964.

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occurs - from 75 to 92 km. The average altitude in all three cases remains almost constant - 83.4 km, 83.1 km, and 82.9 km.

Certain conclusions can be drawn on the basis of determination of the velocities of noctilucent clouds. The horizontal velocities differ widely, and in some cases are very high -- as much as 170 m/sec. (Table 5). The direction of movement of the majority of the points is toward south-west (with the exception of the 1964 appearance, Table 4). This is corroborated by the data obtained in experiments [2] and [3].

The vertical velocities also vary greatly; sometimes they are as high as 20 m/sec and more; this might be caused by strong turbulent movements in the mesopause.

With regard to the displacement of different morphological cloud formations, no definite statement can be made, because of the inadequacy of the obtained data. The greatest amount of data about velocities was obtained for the 1961 appearance (Table 2); at the same time, two speeds were obtained for some points, with an interval between the exposures of two and three minutes respectively. Points 5-14 belong to one

bright strip of noctilucent clouds, and the velocities of all these points practically coincide in magnitude and direction. The vertical velocities of these points are low. Details No. 13-14 are situated at the end of the strip, where they appear in the form of eddies; their vertical and horizontal velocities are higher. Details No. 1-4 are in small combs; their vertical velocities are also high.

TABLE 3

Pair No., beginning of exposure	Detail No.	Altitude in km	Latitude	Longitude
I $02^h10^m00^s$	1	85,4	58°76	26°78
	2	83,0	58,57	26,72
	3	81,1	58,38	26,72
	4	82,5	58,31	26,74
	5	77,5	58,81	26,48
	6	83,2	58,86	26,65
II $02^h12^m00^s$	1	87,0	58,83	26,83
	2	83,5	58,53	26,78
	3	82,9	58,41	26,81
	4	83,3	58,33	26,83
	7	81,5	58,90	26,62
	8	79,8	58,79	26,57
	9	83,1	58,21	26,80
III $02^h14^m00^s$	10	80,5	58,95	26,60
	11	80,8	58,85	26,63
	12	83,4	58,84	26,69
	13	83,8	58,74	26,78
	14	82,3	58,48	26,79
	15	84,7	58,42	26,89
	16	86,4	58,38	26,94
	17	84,5	58,24	26,88
IV $02^h16^m00^s$	18	86,9	58,80	26,88
	19	87,2	58,70	26,96
	20	82,1	58,46	26,84
	21	82,0	58,34	26,86
	22	79,1	58,21	26,77
	23	81,2	58,14	26,82

TABLE 4

Detail No.	Horizontal velocity in m/sec	Vertical velocity in m/sec	Azimuth
3	63 ± 10	13 ± 10	199°
4	48	5	324
5	54	15	239
6	49	7	241

TABLE 5

Sequence No.	Horizontal velocity in m/sec	Vertical velocity in m/sec	Azimuth
1	42 ± 5	-10 ± 5	78°
2	170	-24	9
3	130	-14	17
4	100	-9	21
5	110	-6	26
6	62 ± 10	10 ± 10	290
7	67	-67	280

REFERENCES

1. S.V. Yevdokimenko, Yu.L. Frantsman. Determination of spatial coordinates of noctilucent clouds.
2. G. Witt. Polarization of light from noctilucent clouds. Tellus, 1962, 1.
3. M.A. Dirikis, Ye.Ye. Mukins. Determination of noctilucent clouds' projection onto the earth's surface.

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